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Emerging Nondestructive Evaluation technologies for Bridge and Highway Inspection

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ABSTRACT

The Nondestructive Evaluation (NDE) Section of the Lawrence Livermore National Laboratory has worked with the Federal Highway Administration (FHWA) and California Transportation Administration (Caltrans) to find solutions to inspection of aging bridges and highways. We have demonstrated: ultrasonic methods for inspecting bridge pins; limited view computed tomography for inspecting bridge cables, cable anchors and bridge columns; and we are developing infrared imaging methods for inspecting bridge decks.

We have worked with California Department of Transportation in developing an ultrasonic technique to classify the origin of reflections in two of the pins in the E-9 pier of the San Francisco/Oakland Bay Bridge. These reflections were found during an inspection of the bridge after the Loma Prieta earthquake. We applied our digital signal processing techniques to match the bridge signals with ultrasonic signals from simulated defects in a laboratory reference pin. We confirmed the nature of the ultrasonic reflections to be geometric reflections from the adjoining truss pin support plates. It was concluded that the support plates were fused to the truss pins during the Loma Prieta earthquake providing an interface for ultrasonic reflections.

High energy, x-ray computed tomography (CT) generates cross sectional views of structures. Structures in the field are often not accessible from all sides to allow acquisition of full 360 degree CT data sets. To solve this problem, we developed the reconstruction algorithms and signal processing needed to produce CT images from limited data sets obtained either film or real-time radiography systems. The limited view computed tomography imaging has been applied to bridge cables and bridge cable anchors. A portable accelerator supplied the radiation and film packets captured the two dimensional images. In this demonstration, 23 two-dimensional images were taken over 138 degrees around the cable. The films were digitized, and the digitized data sets were used for CT reconstructions with all views normalized to the same attenuation mass. Locations and amounts of cable separation and loss of mass were displayed.

Lawrence Livermore National Laboratory has pioneered Dual Band Infrared (DBIR) thermal imaging. This technique was developed for remote imaging of hidden structural defects by mapping precise surface temperature-difference patterns in steps of 0.2 degrees Celsius. The DBIR technique uses simultaneous recording of two passive IR bands and unique correction algorithms to decouple temperature from surface emissivity noise. A mathematical approximation derived from Planck's Radiation Law allows the DBIR technology to provide both surface temperature and surface emissivity-ratio images to reduce false detections by locating and removing clutter. These methods are currently being developed to detect defect sites in concrete bridge decks. A stationary feasibility experiment proved that DBIR can image delaminations in simulated concrete bridge decks. This technique is being adapted to a moving vehicle to produce IR images of bridge decks without impeding traffic.

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